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Research on the Application of Artificial Intelligence in Teaching, Practical Training, and Evaluation of Mechanical Engineering Programs in Vocational and Undergraduate Colleges of Jilin Province

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ABSTRACT: *Artificial intelligence (AI) is reshaping teaching, practical training, and evaluation in mechanical engineering vocational education. This paper focuses on mechanical manufacturing and automation, CNC technology, tool and die design, intelligent welding, and industrial robotics programs in Jilin Province, examining how AI technologies can be applied across three domains: intelligent teaching, virtual-real integrated practical training, and data-driven competency evaluation. Drawing on provincial statistics and field observations, the study analyzes the current state of digital teaching infrastructure, graduate employment outcomes, and industry-education integration. It identifies key challenges: limited AI penetration in routine teaching, scarcity of AI-enhanced virtual training resources, lagging intelligent assessment systems, and insufficient faculty capacity for AI-assisted instruction. The paper argues that Jilin should leverage AI to build an intelligent teaching model, AI-driven virtual-real training platforms, and learning-analytic-based evaluation mechanisms, thereby elevating the quality of mechanical engineering technician training and providing talent support for the revitalization of the old industrial base.*

Keywords: Artificial intelligence, Mechanical engineering, Vocational education, Intelligent teaching, Practical training, Learning evaluation, Talent cultivation

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I. INTRODUCTION

Mechanical engineering programs are among the oldest and most industry-connected disciplines in vocational education, directly serving equipment manufacturing, automotive, rail transit, and other real-economy sectors. In December 2022, the General Office of the CPC Central Committee and the General Office of the State Council issued the Opinions on Deepening the Reform of the Modern Vocational Education System, explicitly calling for "substantially improving the quality, adaptability, and attractiveness of vocational education" [1]. In 2023, the National Development and Reform Commission and other ministries jointly issued the Implementation Plan for Enhancing Industry-Education Integration in Vocational Education (2023-2025), positioning industry-education integration as the central lever of reform [2]. The Ministry of Education's 2024 review noted that China's vocational education now offers over 1,400 specialties across more than 120,000 program points, with 6,068 new program points added and 5,052 removed in 2024 alone—an unprecedented pace of dynamic adjustment [14].

In recent years, artificial intelligence has emerged as a transformative force in education. Large language models, intelligent tutoring systems, computer vision, and digital twin technologies are being applied to course delivery, skills training, and competency assessment. For mechanical engineering programs—where hands-on practice, precision measurement, and process evaluation are essential—AI offers particular promise: intelligent tutoring can personalize learning paths for CNC programming, computer vision can automatically inspect machining quality, and learning analytics can provide real-time feedback on student progress. However, adoption in Jilin's vocational colleges remains uneven. As a traditional northeast industrial base and the cradle of China's automotive industry, Jilin is home to FAW Group, CRRC Changchun, and other landmark manufacturing enterprises. The provincial government has advanced the "One Main, Six Duals" strategy and the "464" industrial framework. This paper examines how AI can be systematically applied to teaching, practical training, and evaluation in mechanical engineering vocational and undergraduate programs, identifying challenges and proposing reform pathways.

II. CURRENT STATUS OF MECHANICAL ENGINEERING VOCATIONAL EDUCATION IN JILIN

2.1 Structural Distribution of Talent Training

Over years of development, Jilin has established a multi-level mechanical engineering talent training system encompassing secondary vocational schools, higher vocational colleges, vocational bachelor's programs, and technical schools. In terms of hierarchy, higher vocational colleges form the main body, accounting for over half of total enrollment; secondary vocational and technical schools provide foundational skills training; and vocational bachelor's programs are newly established but growing rapidly. This "pyramid" structure is broadly reasonable, but the apex is weak—vocational bachelor's programs in mechanical engineering are few and small in scale, insufficient to meet enterprise demand for high-level technicians and on-site engineers.

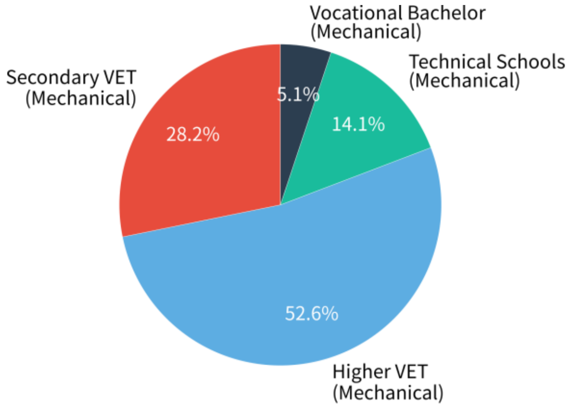

Fig. 1 Structural Distribution of Mechanical Engineering Talent Training in Jilin Province

In terms of training scale, mechanical processing, automotive repair, and CNC technology programs in the province's technical schools account for roughly 40% of total enrollment, sending about 15,000 mechanical graduates annually to FAW, CRRC, and other manufacturing enterprises. Notably, enrollment in secondary vocational mechanical programs has been declining in recent years, with some colleges experiencing difficulty recruiting and retaining students—this decline in student quality poses new challenges for teaching organization and talent quality.

2.2 Graduate Employment and Major-Match Rates

Employment data show that in-province employment rates for mechanical engineering graduates are generally high, above 88%, with automotive inspection and maintenance reaching 94%. However, major-match rates paint a less optimistic picture: industrial robotics graduates have a match rate of only 79%, and tool and die design graduates 82%, both noticeably below their in-province employment rates. This means a substantial share of graduates remain in the province but work in non-matching positions, indicating a mismatch between training and job requirements.

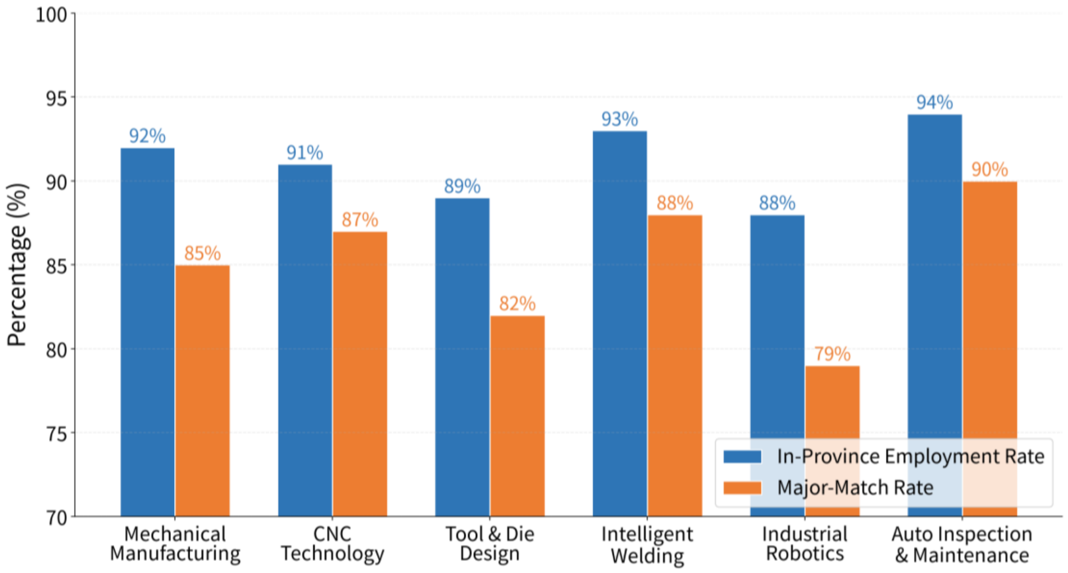

Fig. 2 Graduate Employment by Mechanical Engineering Major

In the author's view, the low match rate stems from multiple factors: first, newer programs like industrial robotics were established recently, with immature curricula, so students' skills lag behind actual job requirements; second, the scale of robotics and intelligent manufacturing industries in Jilin is limited, leaving few matching positions; third, some graduates have employment expectations that differ from available positions. This suggests that program expansion should not blindly follow trends but must carefully consider regional industrial capacity and job supply.

2.3 Progress in Digital Teaching Infrastructure and AI Readiness

Driven by the national digital strategy for vocational education, Jilin's digital teaching infrastructure has improved significantly. Digital teaching platform coverage rose from 58% in 2020 to 92% in 2024, virtual simulation resource libraries grew from 1.2TB to 5.6TB, and annual online training hours increased from 200,000 to 800,000. This trend demonstrates that the digital strategy has taken root in Jilin, with CNC machining simulation, mechanical drawing virtual models, and industrial robotics virtual simulation resources now in use across multiple colleges.

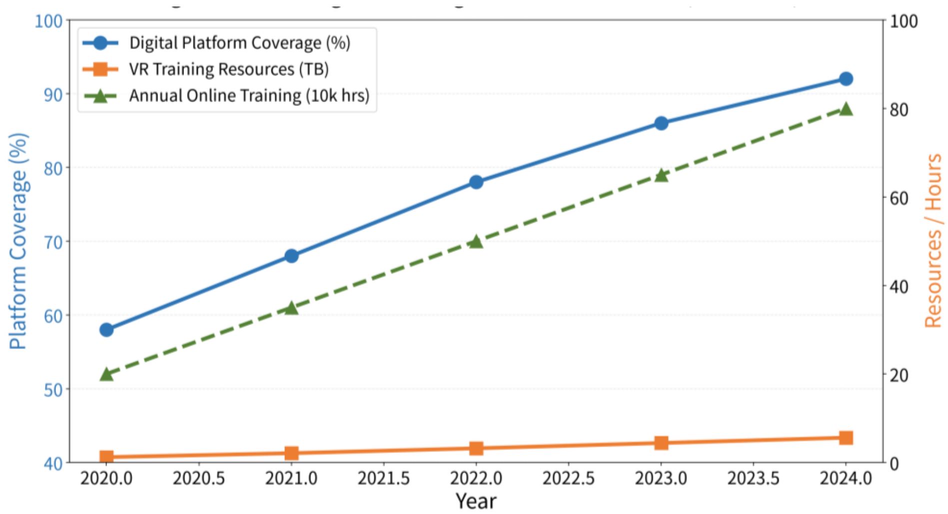

Fig. 3 Growth of Digital Teaching Resources in Jilin VET (2020-2024)

However, it must be recognized that coverage and resource volume growth do not equate to intelligent teaching. The author's field observations reveal that while some colleges have built platforms and purchased resources, AI applications in routine teaching remain sparse: intelligent tutoring systems for CNC programming are rarely deployed, computer-vision-based machining quality inspection is experimental at best, and learning analytics dashboards are largely absent. Most virtual simulation projects merely replicate physical operations on screen, lacking adaptive feedback or inquiry-based learning pathways. The core of AI application lies not in technology itself but in transforming teaching, training, and evaluation models—a point that demands particular attention in mechanical engineering programs.

2.4 Industry-Education Integration Practices

Jilin has actively explored industry-education integration, establishing regional consortia for automotive and chemical industries and industry-education communities for carbon fiber and agricultural machinery. The Changchun regional consortium, for example, brings together FAW, CRRC, Changchun Automobile Vocational and Technical University, and other institutions to collaborate on mechanical engineering talent training.

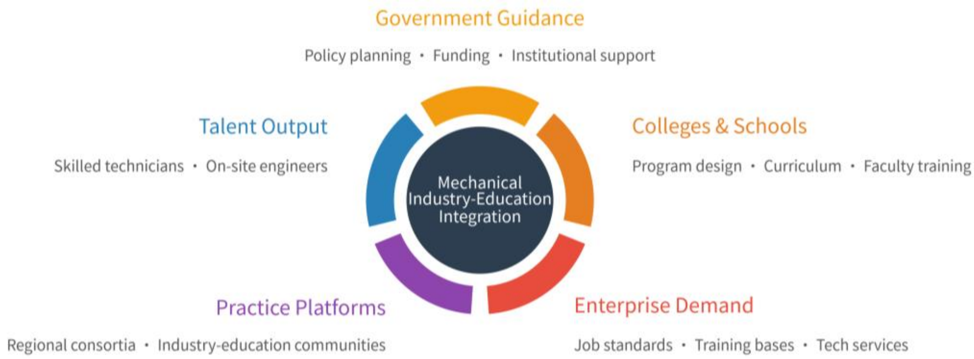

Fig. 4 Industry-Education Integration Framework for Mechanical Engineering Majors in Jilin

From a structural perspective, Jilin's mechanical engineering industry-education integration has formed a four-layer architecture of "government guidance—school-enterprise collaboration—platform support—talent output." In practice, however, connections between layers remain weak. Importantly, leading enterprises such as FAW and CRRC already deploy AI and digital twin technologies on production lines; closing the gap between enterprise-level AI applications and classroom-level AI teaching is a critical task for vocational education reform.

III. KEY PROBLEMS AND CHALLENGES

3.1 Limited AI Penetration in Mechanical Engineering Teaching

There is a structural mismatch between Jilin's mechanical engineering program layout and the "464" industrial framework. On one hand, traditional machining and conventional lathe programs are over-offered; on the other, programs in new energy vehicles, intelligent equipment, industrial robotics, and additive manufacturing lag behind. At the same time, AI-enhanced teaching tools—such as intelligent tutoring systems for CNC G-code programming, AI-assisted mechanical drawing correction, and adaptive learning platforms for materials science—have barely entered the classroom. Faculty typically deliver lectures using static slides, with little use of AI to personalize instruction or provide real-time feedback.

The root cause is "path dependency": colleges tend to build programs around existing faculty and equipment rather than starting fresh based on industry needs. A new AI-enhanced teaching model requires systematic investment in faculty training, platform procurement, and curriculum redesign over a long cycle, while traditional lecture-based teaching continues operating simply because "that is how it has always been done."

3.2 "Superficial" Industry-Education Integration

Despite the establishment of consortia and communities, mechanical engineering school-enterprise cooperation remains "superficial." Many partnerships stop at framework agreements, student visits, and equipment donations, lacking substantive collaboration on co-developed training plans, core curricula, and shared training bases. While FAW and CRRC are willing partners, production confidentiality, safety regulations, and production rhythms limit the depth and duration of student immersion.

The deeper issue is the incentive structure. Enterprises see no short-term return from vocational education participation. In the author's view, industry-education integration cannot rely solely on administrative push; it must establish sustainable benefit mechanisms—allowing enterprises to gain talent pipelines, technical services, and policy dividends from cooperation. AI can serve as a bridge: enterprises can contribute anonymized production data and digital twin models, while colleges use these to build AI-driven training scenarios that directly reflect real production conditions.

3.3 Inadequate AI-Enhanced Practical Training Facilities

Mechanical engineering programs demand high-quality training facilities, but some Jilin colleges—especially at the prefecture and county levels—have outdated equipment and insufficient stations for small-group, project-based teaching. High-end equipment such as CNC machining centers, industrial robots, and coordinate measuring machines is limited. Virtual simulation partially alleviates the shortage of physical training but cannot fully replace hands-on practice.

What is missing is the AI layer on top of virtual simulation. Current virtual simulation projects are largely pre-scripted: students follow fixed steps, and the system checks only whether the final result is correct. An AI-enhanced training system would use computer vision to monitor student operation steps in real time, detect errors in fixturing or tool selection, and provide adaptive hints. It would also use digital twins to simulate rare or high-cost scenarios—such as five-axis machining of complex surfaces—that are impractical to run on physical machines.

3.4 Lagging Intelligent Evaluation and Assessment Systems

Evaluation in mechanical engineering programs remains largely traditional: written exams for theory, and subjective instructor grading for practical skills. There is a notable absence of data-driven, continuous assessment. For CNC programming, evaluation typically consists of a single final project; for welding, it relies on visual inspection by instructors; for mechanical design, it is based on a single drawing assignment.

The author believes that AI can transform evaluation in three ways: first, automated grading of CNC code and CAD models using rule-based and ML systems; second, computer-vision-based assessment of welding quality and machining precision from camera feeds; third, learning analytics that track student progress across courses, identify knowledge gaps, and provide early warning of at-risk students. Such continuous, multi-dimensional evaluation would provide a more accurate picture of student competency than traditional summative assessments.

3.5 Faculty Capacity Gap in AI-Assisted Instruction

Dual-qualified faculty are critical to mechanical engineering teaching quality, but a new gap has emerged: most current faculty have neither the technical background to use AI teaching tools nor the pedagogical training to design AI-enhanced curricula. Many faculty enter teaching directly from graduate school without manufacturing industry experience, and even fewer have experience with large language models, learning analytics platforms, or digital twin systems.

While teacher enterprise practice policies exist, implementation sometimes amounts to "going through the motions." Ensuring that faculty genuinely acquire AI teaching competencies—through targeted training, co-development of AI courseware with technical partners, and long-term exchange with enterprises that deploy AI on production lines—remains an unresolved issue.

IV. REFORM PATHWAYS AND RECOMMENDATIONS

4.1 Build AI-Enabled Intelligent Teaching Model

Mechanical engineering teaching should be reimagined with AI as an enabling layer. Jilin should pilot intelligent tutoring systems in core courses such as CNC programming, mechanical design, and materials science. These systems can provide personalized practice problems, step-by-step hints, and instant feedback, freeing instructors to focus on higher-order guidance. AI-assisted tools can also automatically grade CAD drawings and CNC code, reducing instructor workload and providing consistent, objective evaluation.

In curriculum reform, faculty should conduct deep job analysis to translate real enterprise tasks into curriculum modules, building a modular, project-based curriculum system. AI-generated learning content—such as virtual machining scenarios, adaptive quiz banks, and interactive 3D model explanations—should be integrated into course delivery. Aligning with national teaching standards, practical instruction hours should not fall below 50% of total hours for secondary and higher vocational programs, or 60% for vocational bachelor's programs.

4.2 Substantive Industry-Education Integration with AI as a Bridge

Industry-education integration must move beyond framework agreements toward substantive operation. The Changchun automotive regional consortium should establish a council system with FAW, CRRC, and other enterprises deeply involved in training plan design, core curriculum development, and training base construction. AI can serve as a bridge: enterprises contribute anonymized production data, digital twin models, and process parameters; colleges use these to build AI-driven training scenarios that mirror real production lines.

In "jobs-curriculum-competitions-certificates" integration, position job needs as the starting point, curriculum as the core, competitions as the lever, and certificates as the evaluation, forming a four-in-one model (Fig. 5). AI can enhance each link: intelligent systems can generate competition-style practice problems, evaluate student performance against competition standards, and map certificate requirements to course modules.

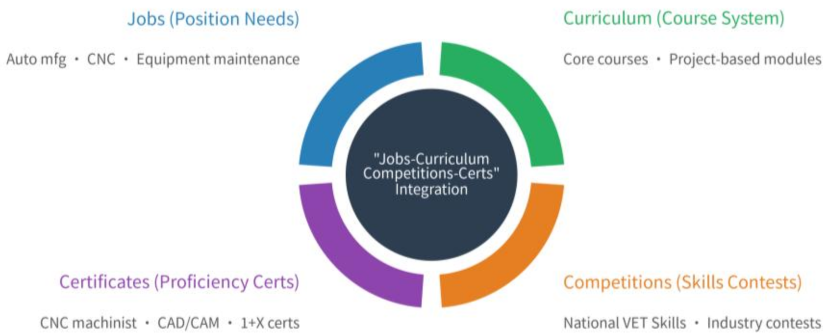

Fig. 5 "Jobs-Curriculum-Competitions-Certificates" Integrated Training Model

4.3 Develop AI-Driven Virtual-Real Integrated Practical Training Platforms

Digital transformation is not simply purchasing equipment and building platforms but using AI to solve real teaching problems. Jilin should strengthen digital renovation of mechanical training bases, building digital twin factories, industrial robotics training centers, and intelligent production line facilities. On top of these physical facilities, deploy AI layers: computer vision systems that monitor student operations in real time, digital twin simulations that predict machining outcomes before physical cutting, and adaptive guidance systems that adjust difficulty based on student performance.

Develop high-quality AI-enhanced virtual simulation resources for high-risk or high-cost training such as CNC machining and welding, applying the principle of "virtual for practical, virtual to complement practical." Use virtual simulation to build operational skills and safety awareness before physical hands-on training, reducing costs while improving safety. AI algorithms can analyze student interaction logs to identify common error patterns and refine training scenarios accordingly.

4.4 Establish Data-Driven Intelligent Evaluation System

Evaluation should shift from summative, subjective assessment to continuous, multi-dimensional, data-driven evaluation. Jilin should pilot an intelligent evaluation system across mechanical engineering programs that combines: (1) automated grading of CNC code and CAD models; (2) computer-vision-based assessment of welding quality and machining precision; (3) learning analytics dashboards that track student progress across courses and identify at-risk students early; (4) enterprise-informed competency standards that ensure evaluation aligns with real job requirements.

Such a system would provide students with real-time feedback, instructors with actionable teaching insights, and administrators with program-level quality indicators. Over time, accumulated data can also inform curriculum revision, program adjustment, and faculty development—closing the loop between evaluation and improvement.

4.5 Build AI-Competent Dual-Qualified Faculty Teams

Faculty development is the foundation of AI-enhanced teaching reform. Jilin should refine mechanical teacher hiring standards, requiring new faculty to have prior enterprise work experience or relevant professional qualifications, and increasingly, familiarity with AI teaching tools. Implement substantive enterprise practice—clearly defining tasks, assessment criteria, and deliverable so that faculty genuinely engage with AI applications on production lines rather than going through the motions.

In faculty evaluation, break the "papers-titles-degrees" orientation by including AI courseware development, intelligent teaching platform usage, and student learning analytics outcomes in performance reviews. Partner with Jilin Engineering Normal University and technology enterprises to offer targeted training on AI-assisted teaching, digital twin authoring, and learning analytics. Build teaching innovation teams that combine mechanical engineering expertise with AI literacy, promoting two-way exchange between college teachers and enterprise technicians.

V. CONCLUSION AND OUTLOOK

Teaching reform in mechanical engineering vocational education is a systematic project involving program structure, curricula, training facilities, evaluation, and faculty. Jilin has established a comprehensive training system and made notable progress in digitalization. However, limited AI penetration in teaching, inadequate AI-enhanced training facilities, lagging intelligent evaluation systems, and faculty capacity gaps remain prominent challenges. These problems cannot be solved by isolated measures but require coordinated, systematic reform centered on AI application.

Looking ahead, as Jilin's automotive industry accelerates its transition to new energy intelligent connected vehicles, demand for AI-literate mechanical engineering technicians will continue to grow. The province should seize this opportunity to build AI-enabled intelligent teaching models, AI-driven virtual-real training platforms, and data-driven evaluation systems. The success of reform will ultimately be measured by whether every mechanical engineering graduate acquires genuine skills, receives personalized guidance, and secures quality employment—only then can Jilin's vocational education reform truly serve the revitalization of the old industrial base.

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